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March 18, 1993
Project Number S113107

Barneys Canyon Mine
P.O. Box 311
Bingham Canyon, Utah
84006-0311

Attention: Dave Hodson

Dear Mr. Hodson:

RE: ACID BASE ACCOUNTING AND SHAKE FLASK TESTING RESULTS

This memo presents our conclusions and recommendations from the recent testing of samples from the South Barneys Canyon - South Deposit.

A total of 40 samples were collected from blast hole cuttings at the site. These samples were distributed uniformly over 10 drill holes, and at depths of 10, 20, 30 and 40 feet. The uniform distribution of samples adequately represents the material excavated from this area. Eight samples were sent to Chemex Laboratories in North Vancouver, British Columbia and 32 samples were sent to Core Laboratories in Aurora, Colorado for acid base accounting tests. Two composite samples were prepared from the Chemex samples, and were submitted for short term leach extraction tests.

Acid Base Accounting Test Results

Table 1 presents the acid base accounting results, sorted by NNP. A discussion of the criteria for interpretation of the test was provided in our letter to Dave Hodson, dated January 15, 1993. The following has been extracted from that letter:

> Acid base account tests are used to define the balance between potentially acid generating minerals (sulfides) and potentially acid consuming minerals (typically carbonates) in a sample. Theoretically a sample will only generate acidic leachate if the potential for acid generation (AP) exceeds the neutralization potential, (NNP) or an NP/AP ratio of less than 1. However, in a rock pile, the physical distribution of the potentially acid generating and acid neutralizing minerals may be sufficiently variable that acidic seeps may develop for NP/AP ratios greater than 1. For mine rock piles, it is generally accepted that samples with an NP/AP of less than 3:1 (but greater

than 1) do not clearly indicate a potential for acid generation. It is our opinion that where the sulfide and base mineralization is disseminated fairly uniformly in the rock mass (as is the case at Barneys Canyon) and is not concentrated on joints, that this ratio can be reduced to 2:1. A similar index based on NNP is used, where samples in the range of +20 to -20 kg $CaCO_3$ equivalent/tonne are in this uncertain range. If a sample falls within this range, kinetic testing is generally required to determine the likelihood for contaminant release and acid generation. In addition where sulfide sulfur is low, generally less than 0.1%, it is considered that the potential for acid generation is insignificant, even if no NP is available. In this case, however, metal leaching may still pose a potential concern.

An additional consideration is the apparently low reactivity of the sulfides remaining in the rock. There are indications that the material to be mined from the South Barneys Canyon - South Deposit has already been exposed to a certain amount of chemical weathering. The majority of the material to be mined is above the natural groundwater table and the porous nature of the rocks has allowed air and water to reach sulfide particles within the rock mass. Any reactive sulfide particles would have likely already oxidized to sulfate. Therefore it is considered likely that any remaining sulfides have a relatively low reactivity.

Test results from the recent samples indicate the overall potential for acid generation is low. In a well blended rock pile, there would be a net positive NNP, and a net NP:AP ratio of 2.1. The distribution of potentially acid producing and acid consuming materials is however not uniformly distributed in the rock to be mined:

- 5/40 samples tested would be considered likely to produce acidity;

- 9/40 samples have a potential to generate acidity, but have sufficiently low sulfide contents that the net acidity produced would be very low;

- 5/40 samples are in the uncertain range for acid generation, where kinetic tests are required to determine the likelihood of acid generation. However, these samples have such a small proportion of sulfide and neutralizing minerals that they are considered "inert", or non-reactive;

- 10/40 samples are non acid producing, however the total NP of these samples is relatively low, therefore the samples are not considered acid consumers; and,

- 11/40 samples are acid consuming.

Because the potentially acid generating rock (HH10) is not located spatially near to the neutralizing materials (HH3, HH4 and HH8), there is some concern that a well blended pile would be difficult to produce. Selected removal of some of the potentially acid producing materials would provide some assurance that the blend of 2:1 can be maintained uniformly throughout the pile. For example, if the material in the vicinity of the HH10 drill hole were removed and hauled to the strongly acid consuming Barneys Canyon Mine piles, the overall NP:AP ratio remaining would be approximately 3:1.

Ms. Heppler indicated that the iron enriched areas within the pit are distributed in a random clustered pattern, possibly with a weak structural control, rather that an easily identified lithologic pattern. It would probably be very difficult to segregate materials based on their acid potential.

We feel that while there is the potential for localized zones of acid generating materials: the low reactivity of the sulfides and the overall composition of the pile will prevent the development of acidic drainage, even at a 2:1 ratio, provided an even blend can be maintained. If it is not possible to maintain the blend, the material which is likely to produce acidity could be selectively removed and hauled to an alternative disposal site.

Short Term Extraction Tests

Extraction tests, or "shake flask" tests are used to quantify the total contaminant load available for dissolution. The test does not quantify the rate of release over time.

Two composite samples were prepared from the samples sent to Chemex laboratories. These represent material with a "high" and moderate sulfate content. The samples were mixed with a weak acidic leachate (pH 4.2) at a solution to solids ratio of 2:1, agitated for 24 hours, filtered and analyzed for pH, conductivity, sulfate, alkalinity, and metals by ICP. The detailed procedure used by Chemex is attached. Test results are presented in Tables 2 and 3.

Test results indicate a very rapid response of neutralizing minerals to the weak acid leachate. The pH of the final solution for both samples was greater than 8.0. Alkalinity levels reached 43 and 30 mg/L $CaCO_3$ equivalent respectively for each of the samples. The rapid response of pH and alkalinity to the acidic leachate used for the test, indicates the samples would respond rapidly in the field to neutralize any acidic seepage developing within the rock pile. Conductivity levels were elevated to levels exceeding 170 umhos/cm, this high conductivity represents soluble salts, including the sulfate and other ionic species in solution.

Sulfate levels in the final leachate were 26 and 24 mg/L respectively. As there was a small amount of sulfate (from the sulfuric acid) in the original leachate, this represents a net sulfate release of 22 and 20 mg/L, or a maximum soluble load of about 40 mg/kg of rock, under the relatively aggressive testing conditions. It is our experience that only a small portion of the maximum soluble load is released under normal conditions in dry deposited rock piles. However, when this is magnified to the tonnages of waste rock in the piles, even a small percentage release of the sulfate could represent a significant concentration (on the order of 1000 mg/L) discharging from the pile. It is our opinion that any release of sulfates would be over the short term, and would be sufficiently diluted by the regional surface and groundwaters to mitigate any impact to the downstream system.

Metal concentrations in the final leachate were generally very low. An appreciable amount of calcium was released, probably due to dissolution of carbonate minerals. Trace levels of arsenic, nickel and molybdenum were detected in the HH1 composite. The solids analysis indicates there is a significant quantity of arsenic available for release, however the tests indicate only a small portion is readily soluble. It appears that there is very little concern with respect to metal leaching from material represented by these sample composites.

Summary and Recommendations

Based on the recent test results, the material represented by the test samples should present no significant concerns in terms of acid generation or water quality in a well blended pile. It is critical that this blend is maintained at an NP:AP ratio of greater than 2:1, therefore, if blending cannot be achieved on a small scale (<1 meter separation), selected removal of the sulfide enriched material is recommended.

In the absence of acid generation, there is a potential for a short term release of sulfate from rock dumps. To avoid flushing from the dump, we recommend that the dump be placed so as to fill the base of the valley allowing the stream flow to be directed, in a channel, over the dump. In this manner, impoundment behind the dump and the associated seepage and leaching is eliminated.

The 32 sample rejects, from the testing at Core Laboratories, have been sent to Cominco Engineering Services Laboratories in Vancouver (CESL). The samples should represent coarser grained material from the drill cuttings. We recommend the following 5 samples or sample composites be submitted for shake flask testing:

- HH10 (10, 20, 30)
- HH09 (20, 30, 40)
- HH04 (10, 20, 40)
- HH08 (20, 30, 40)
- HH07 (10, 20, 30)

The testing procedure used for the previous samples (at Chemex) is recommended. Additionally, paste pH tests should be done on all 32 original samples. CESL generally charges us for the labour only for these tests, @$29/hr. I think all of them could be done within 2 hours.

Please call if you have any questions or comments.

Yours truly

STEFFEN ROBERTSON AND KIRSTEN (CANADA) INC.

A. MacG. Robertson, P.Eng.
Principal

KSS/LMB/AMR
073/kss

TABLE 1
BARNEYS CANYON MINE, ACID BASE ACCOUNTING

SORTED BY NNP - ALL SAMPLES

Sample	Depth (ft)	S (tot) %	S (SO4) %	S (S 2-) %	AP	NP	NNP	NP/AP
HH10	10	0.9	0.33	0.57	17.8	2.7	-15.1	0.15
HH10	30	0.9	0.42	0.48	15.0	0.8	-14.2	0.05
HH10	20	0.79	0.29	0.50	15.6	1.8	-13.8	0.12
HH09	20	0.5	0.12	0.38	11.9	1.8	-10.1	0.15
HH07	10	1.89	1.54	0.35	10.9	1.8	-9.1	0.16
HH09	40	0.84	0.63	0.21	6.6	1.8	-4.8	0.27
HH07	40	0.4	0.2	0.20	6.3	1.8	-4.5	0.29
HH09	30	1.04	0.92	0.12	3.8	0.4	-3.4	0.11
HH05	20	0.24	0.06	0.18	5.6	2.5	-3.1	0.44
HH02	30	0.194	0.08	0.11	3.6	1	-2.56	0.28
HH02	40	0.266	0.17	0.10	3.0	1	-2.00	0.33
HH03	10	0.6	0.04	0.56	17.5	15.8	-1.7	0.90
HH02	20	0.23	0.13	0.10	3.1	2	-1.13	0.64
HH05	10	0.11	<.01	0.11	3.4	3.3	-0.1	0.96
HH06	40	0.13	0.06	0.07	2.2	2.3	0.1	1.05
HH06	10	0.08	0.02	0.06	1.9	2	0.1	1.07
HH01	40	0.418	0.30	0.12	3.7	4	0.31	1.08
HH05	30	0.12	0.02	0.10	3.1	3.5	0.4	1.12
HH05	40	0.06	0.02	0.04	1.3	1.8	0.6	1.44
HH07	20	1.47	1.46	0.01	0.3	1.8	1.5	5.76
HH06	30	0.03	0.02	0.01	0.3	1.8	1.5	5.76
HH10	40	0.28	0.31	0.00	0.0	1.8	1.8	>18
HH07	30	0.66	0.69	0.00	0.0	1.8	1.8	>18
HH09	10	0.4	0.33	0.07	2.2	4.3	2.1	1.97
HH01	10	0.558	0.47	0.09	2.8	5	2.25	1.82
HH01	30	0.626	0.57	0.06	1.8	6	4.25	3.43
HH06	20	0.01	<.01	0.01	0.3	4.8	4.5	15.36
HH08	10	0.04	0.04	0.00	0.0	4.8	4.8	>48
HH02	10	0.035	0.03	0.01	0.2	6	5.84	38.40
HH03	20	0.13	0.04	0.09	2.8	10.4	7.6	3.70
HH04	30	0.1	<.01	0.10	3.1	10.9	7.8	3.49
HH01	20	0.519	0.47	0.05	1.5	13	11.47	8.49
HH04	20	0.05	<.01	0.05	1.6	16.7	15.1	10.69
HH04	40	0.08	0.02	0.06	1.9	20.5	18.6	10.93
HH04	10	0.05	0.05	0.00	0.0	23.6	23.6	>236
HH08	20	0.09	<.01	0.09	2.8	28.6	25.8	10.17
HH03	30	0.13	0.02	0.11	3.4	29.9	26.5	8.70
HH08	30	0.07	0.05	0.02	0.6	27.1	26.5	43.36
HH03	40	0.14	0.02	0.12	3.8	38.5	34.8	10.27
HH08	40	0.02	0.01	0.01	0.3	37.7	37.4	120.64
AVERAGE (NET ROCK PILE COMPOSITION)					4.1	8.7	4.5	2.1

TABLE 2

BARNEYS CANYON MINE, SHAKE FLASK TEST RESULTS

Leaching Solution:

pH	4.2
Conductivity (umhos/cm)	21.7
Sulphate (SO4) (mg/L)	4.2

Test Results:

Parameter	HH1 Comp	HH2 Comp
pH (after 1 hour of contact)	8.6	8.2
pH (after 2 hours of contact)	8.6	8.2
pH (Final)	8.4	8.2
Conductivity (umhos/cm)	192	177
Alkalinity (mg/L CaCO3 eq.)	43	30
Net Sulphate (SO4) (mg/L)	22	20

METALS (mg/L)

	HH1 Comp	HH2 Comp
As	0.05	< 0.05
Ba	0.3	0.1
Ca	21	10
Cu	< 0.01	< 0.01
Fe	< 1	< 1
K	5	5
Mg	4	2.8
Mn	< 0.01	< 0.01
Mo	0.34	0.02
Ni	0.05	0.04
P	< 1	< 1
Pb	< 0.05	0.05
Sr	0.11	0.07
Zn	< 0.01	< 0.01

* Selected metals not included (metals where the solids content was below detection limit)

TABLE 3

BARNEYS CANYON MINE, SHAKE FLASK TEST RESULTS: CALCULATIONS

Parameter	Solids (mg/kg)		Leachate (mg/L)		Load (mg/kg)		% Extraction	
	HH1 Comp	HH2 Comp	HH1 Comp	HH2 Comp	HH1 Comp	HH2 Comp	HH1 Comp	HH2 Comp
SO4	4500	1000	22	20	44	40	0.98	4.00
As	178	160	0.05	< 0.05	0.1	< 0.1	0.06	< 0.06
Ba	520	1520	0.3	0.1	0.6	0.2	0.12	0.01
Ca	1500	800	21	10	42	20	2.80	2.50
Cu	6	6	< 0.01	< 0.01	< 0.02	< 0.02	< 0.33	< 0.33
Fe	13100	21700	< 1	< 1	< 2	< 2	< 0.02	< 0.01
K	1600	1200	5	5	10	10	0.63	0.83
Mg	700	500	4	2.8	8	5.6	1.14	1.12
Mn	15	115	< 0.01	< 0.01	< 0.02	< 0.02	< 0.13	< 0.02
Mo	2	2	0.34	0.02	0.68	0.04	34.00	2.00
Ni	4	24	0.05	0.04	0.1	0.08	2.50	0.33
P	80	70	< 1	< 1	< 2	< 2	< 2.50	< 2.86
Pb	20	12	< 0.05	0.05	< 0.1	0.1	< 0.50	0.83
Sr	56	45	0.11	0.07	0.22	0.14	0.39	0.31
Zn	14	170	< 0.01	< 0.01	< 0.02	< 0.02	< 0.14	< 0.01

TABLE 4
BARNEYS CANYON MINE, ACID BASE ACCOUNTING

SORTED BY NNP - HH10 REMOVED

Sample	Depth (ft)	S (tot) %	S (SO4) %	S (S 2-) %	AP	NP	NNP	NP/AP
HH09	20	0.5	0.12	0.38	11.9	1.8	-10.1	0.15
HH07	10	1.89	1.54	0.35	10.9	1.8	-9.1	0.16
HH09	40	0.84	0.63	0.21	6.6	1.8	-4.8	0.27
HH07	40	0.4	0.2	0.20	6.3	1.8	-4.5	0.29
HH09	30	1.04	0.92	0.12	3.8	0.4	-3.4	0.11
HH05	20	0.24	0.06	0.18	5.6	2.5	-3.1	0.44
HH02	30	0.194	0.08	0.11	3.6	1	-2.56	0.28
HH02	40	0.266	0.17	0.10	3.0	1	-2.00	0.33
HH03	10	0.6	0.04	0.56	17.5	15.8	-1.7	0.90
HH02	20	0.23	0.13	0.10	3.1	2	-1.13	0.64
HH05	10	0.11	<.01	0.11	3.4	3.3	-0.1	0.96
HH06	40	0.13	0.06	0.07	2.2	2.3	0.1	1.05
HH06	10	0.08	0.02	0.06	1.9	2	0.1	1.07
HH01	40	0.418	0.30	0.12	3.7	4	0.31	1.08
HH05	30	0.12	0.02	0.10	3.1	3.5	0.4	1.12
HH05	40	0.06	0.02	0.04	1.3	1.8	0.6	1.44
HH07	20	1.47	1.46	0.01	0.3	1.8	1.5	5.76
HH06	30	0.03	0.02	0.01	0.3	1.8	1.5	5.76
HH07	30	0.66	0.69	0.00	0.0	1.8	1.8	>18
HH09	10	0.4	0.33	0.07	2.2	4.3	2.1	1.97
HH01	10	0.558	0.47	0.09	2.8	5	2.25	1.82
HH01	30	0.626	0.57	0.06	1.8	6	4.25	3.43
HH06	20	0.01	<.01	0.01	0.3	4.8	4.5	15.36
HH08	10	0.04	0.04	0.00	0.0	4.8	4.8	>48
HH02	10	0.035	0.03	0.01	0.2	6	5.84	38.40
HH03	20	0.13	0.04	0.09	2.8	10.4	7.6	3.70
HH04	30	0.1	<.01	0.10	3.1	10.9	7.8	3.49
HH01	20	0.519	0.47	0.05	1.5	13	11.47	8.49
HH04	20	0.05	<.01	0.05	1.6	16.7	15.1	10.69
HH04	40	0.08	0.02	0.06	1.9	20.5	18.6	10.93
HH04	10	0.05	0.05	0.00	0.0	23.6	23.6	>236
HH08	20	0.09	<.01	0.09	2.8	28.6	25.8	10.17
HH03	30	0.13	0.02	0.11	3.4	29.9	26.5	8.70
HH08	30	0.07	0.05	0.02	0.6	27.1	26.5	43.36
HH03	40	0.14	0.02	0.12	3.8	38.5	34.8	10.27
HH08	40	0.02	0.01	0.01	0.3	37.7	37.4	120.64
AVERAGE (NET ROCK PILE COMPOSITION)					3.3	9.4	6.2	2.9